MESOZOIC FOSSILS FROM THE SNAKE RIVER, CENTRAL NEW GUINEA.

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(Plates XIV–XV, text-figures 1–7.)

INTRODUCTION.

In 1943 Dr. F. W. Whitehouse, then on active military service in the area of operations between Wau and Lae (New Guinea), discovered fossils in phyllitic strata outcropping along the Snake River approximately 20 miles north-north-west of Wau. These beds had been mapped by Fisher (1944) as part of the " Kaindi Series " which was described as a series of more or less altered unfossiliferous rocks and placed tentatively in the Palæozoic. Dr. Whitehouse was unable to undertake a detailed study of the fossils as most of the specimens collected by him failed to reach Australia. He informed a number of his colleagues of his discovery and early in 1946 pointed out the exact locality to the present writer. Later, in a letter to Dr. K. Washington Gray, Chief Geologist of the Australasian Petroleum Company, Dr. Whitehouse stated that he had identified one of the remaining specimens in his collection as *Inoceramus*.

Thus, Dr. Whitehouse, the first discoverer of fossils in this area, was also the first to recognise among them a Mesozoic genus.

In order to obtain confirmation of these important discoveries, Dr. K. Washington Gray arranged for Mr. G. A. V. Stanley, D.S.C., Senior Geologist of the Australasian Petroleum Company, to proceed to the Snake River in September, 1946, for the purpose of collecting fossils and making further geological observations. By permission, the following description of his observations is reproduced here :—

" During Mr. Stanley's visit he collected 53 specimen bags of rock, and 9 other large pieces.

" The rocks are all more or less schistose, varying from very dark, graphitic and slaty schists, to brown phyllites and greenish-grey or dark-bluish-grey sandy (even gritty) rocks in which the bedding is still clearly apparent. The fossils are more abundant in the latter types, and in road cuttings can be seen as lines of cavities parallel to the bedding planes. On hillsides the cavities left by the fossils are easily found if careful search is made in the outcrops, and it is certainly surprising that their presence has not been earlier detected. For his part, Mr. Stanley has always directed his attention to searching for fossils in the calcareous (limestone and marble) bands in the Kaindi Series, and has unconsciously neglected the more argillaceous and sandy types.

" Mr. Stanley found no limestones interbedded in the thickness of 1,500 feet of rocks, over which his collecting extended. Fisher's map shows limestone lenses at the head of the Snake River.

" Igneous rocks are present in the area. Grey granite intrudes the schists between Sunshine and the Watut-Snake junction (Fig. 1), and at Gurukor Village there is a large mass of grey granite, evidently also part of the Morobe batholith. Boulders of a coarsely crystalline basic plutonic rock were found in a creek-bed not far from Mumeng.

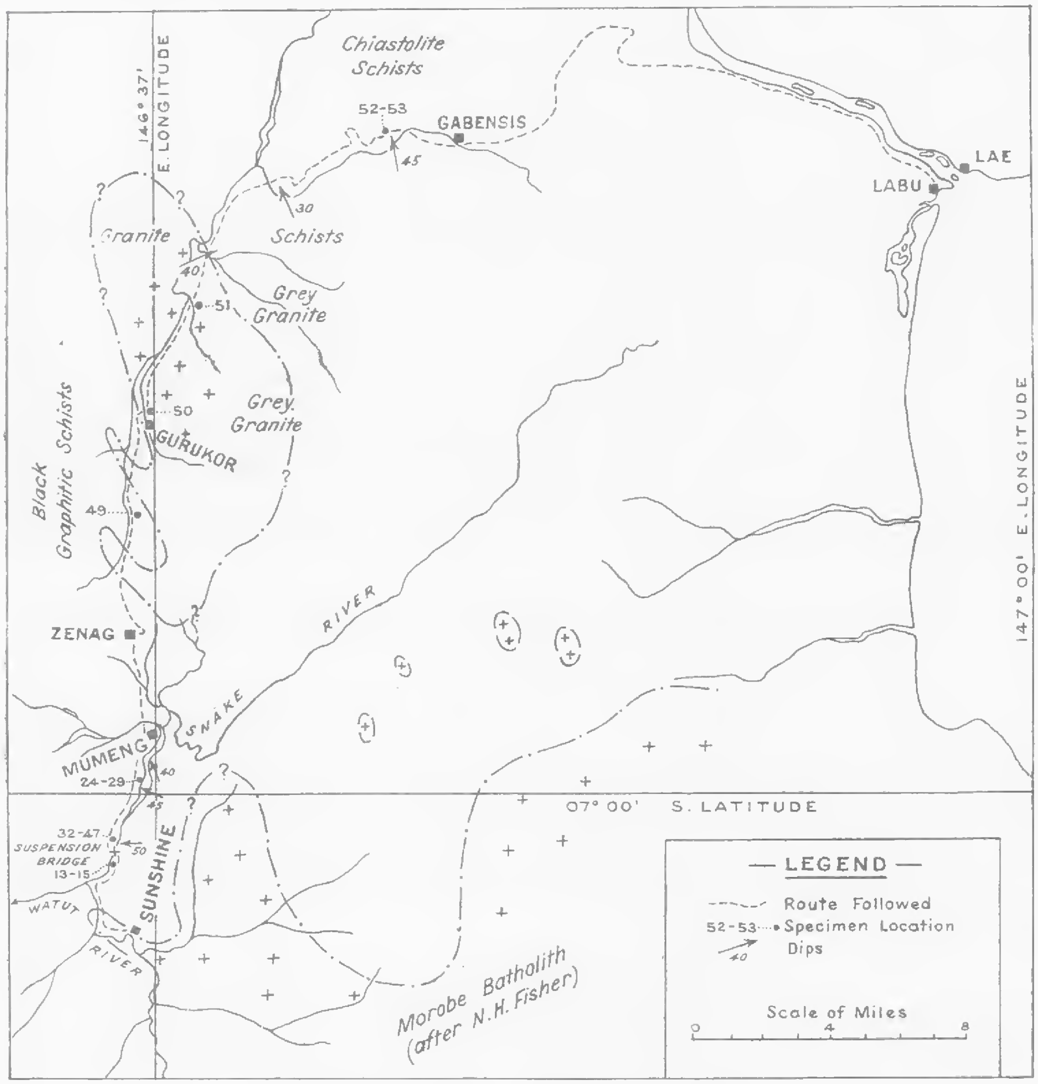

Fig. 1.—Locality map, by G. A. V. Stanley.

" Structurally, the beds from which the fossils are derived are comparatively simply arranged. They dip westwards at angles from 35° to vertical, and where massive sandy beds are present the bedding is well preserved. In the fine argillaceous facies foliation and contorting is apparent, especially close to granite contacts. The streams everywhere tend to conform to the strike of the beds. Faulting is common but does not seem to be of very great extent.

" No adequate description can be given here of the terraces of angular detrital material, hundreds of feet thick, which have filled the valley of the Snake River

between Zenag and the Watut Junction, and which are now well dissected by the present cycle of erosion. The deposits are typical of fanglomerates, but near Zenag the size and shape of the constituent blocks strongly suggests a tillite."

A specimen of the fossiliferous rock was submitted for petrological examination to Dr. A. B. Edwards, of the Mineragraphic Section, Council for Scientific and Industrial Research, Melbourne. He gave the following description of a thin section :—

" The shells occur in a fissile, hard, grey-black rock. It has a cleaved structure, and consists essentially of angular grains of quartz and more or less altered felspar, with minor amounts of biotite, muscovite, chlorite, tourmaline, zircon, apatite, leucoxene, and epidote, together with occasional rock fragments, in a matrix of sericite, fine-grained quartz and felspar, chlorite and carbonaceous matter. The rock has been extensively invaded by carbonate along the cleavage directions which are inclined to each other at about 30-40°.

" The quartz grains are about 0·2 mm. long or smaller. Some are equidimensional but many are elongated parallel to the general direction of cleavage, and some are fractured at right angles to their elongation as a result of stretching. Occasional stretched grains are bent, others are sharply separated at the fractures, which are filled with sericite or carbonate. Many of the grains have delicate projections, and their angularity may be due in part to shearing. They show little or no strain or granulation.

" The felspar about equals the quartz in abundance and is partly orthoclase, partly an acid plagioclase (oligoclase). It is cloudy from alteration to sericite, and some grains are completely altered to a lattice of sericite blades. The plagioclase appears less altered than the orthoclase. The grain size is similar to the quartz.

" These grains are cemented together by a matrix of sericite, fine-grained quartz and felspar, occasional films of chlorite, and carbonaceous matter. The other minerals present occur scattered throughout this matrix, the micas tending to lie parallel to the cleavage directions. The carbonaceous matter occurs as strings in the grain boundaries and emphasises the cleavage directions of the rock.

" The rock fragments consist of fine-grained chert-like material, quartzite, carbonaceous shale (?) and granite (?). One fragment of carbonaceous shale is horseshoe-shaped, as though rolled like the fossils. One fragment of (?) granite consists of interlocking grains of quartz, oligoclase and orthoclase, another consists of interlocking plagioclase and orthoclase.

" It is probable that the rock is not greatly different in general composition and characters from the Purari greywackes (Edwards 1947). It is clearly ill-sorted, the grains are angular, and the source material was largely granitic. The name " schist " is ill-chosen for such rocks. They would be better described as cleaved felspathic sandstones or greywackes. There has been no recrystallization of the constituents as would be expected in a schist."

OCCURRENCE AND PRESERVATION OF FOSSILS.

The fossils are not evenly spread through the rock but occur in local concentrations and fossiliferous layers. Some shells were unbroken and there are no signs of wear and abrasion, but many were embedded in the matrix as fragments. Most of the lamellibranchs are preserved as single valves, but one specimen of *Cucullaea* consisted of both valves, which were only slightly displaced before the sediment was lithified. The larger and heavier shells do not lie in the bedding planes. The occurrence of the fossils indicates rapid deposition in shallow water, which agrees with the ill-sorted composition of the sediment.

All molluscan shells were replaced by crystalline calcite, which is mostly closely welded to the surrounding sediment. This makes identification of the fossils difficult. Weathering, however, has dissolved the calcite, leaving remarkably clearcut casts and moulds.

The fossils are very much distorted. The general effect is apparently a strong compression at right angles to the bedding planes and intense stretching in one direction along the bedding planes. The resulting deformation is particularly striking in the case of large *Cucullaea* and *Trigonia* shells originally embedded in the rock at an angle to the bedding plane. The distortion of some of the figured specimens is explained in text-figure 2. As the known shape of the fossils makes it possible to

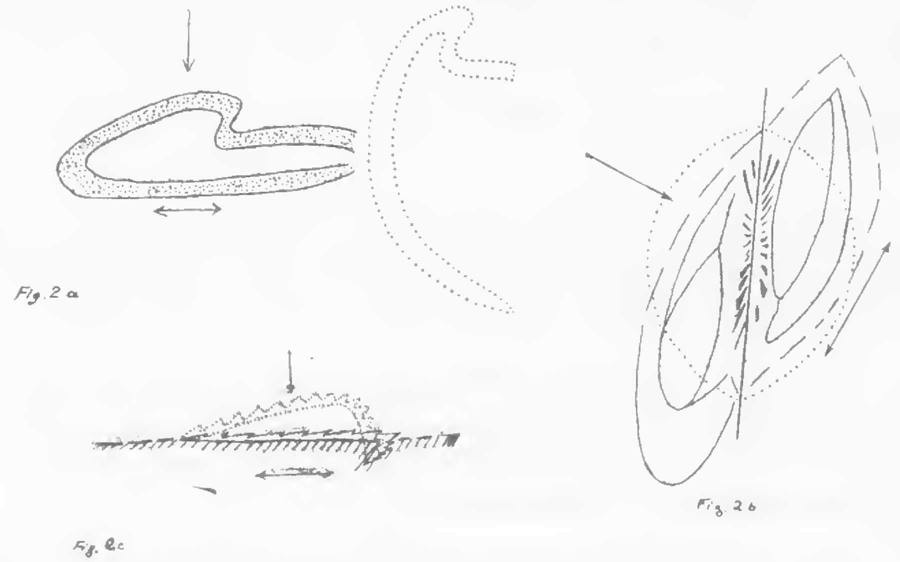

Fig. 2.—Examples of distortion of Snake River fossils—

a—*Cucullaea* (*Ashcroftia*) *distorta* sp. nov. Cross section of specimen pl. XIV. fig. 1 with superimposed reconstructed section showing little change in length and width.

b—Same species, cross section of specimen pl. XIV fig. 2 with superimposed reconstructed section.

c—*Trigonia* (*Acanthotrigonia*) *phyllitica* sp. nov. Cross section of specimen pl. XV fig. 1 and reconstructed section.

reconstruct the original shape of a fossiliferous rock specimen prior to its deformation, a detailed study of this deformation including the relation of rock texture, cleavage, &c., to local and regional direction of stress as revealed by the folding of the fossiliferous strata and by the structural behaviour of the intruding batholith would be particularly fruitful. For this purpose it would be necessary to take oriented specimens in the field. Such specimens are not at present available.

The most striking feature is the preservation of fine detail concurrently with intense distortion of the general outline and proportions of the shells. This is due to the replacement of the original shell material by crystalline calcite prior to the stress action. The calcite crystals yielded to the stress by slip movements along cleavage planes. They were not granulated and did not wedge or thin out in the same manner in which the sandy and argillaceous freely yielding matrix reacted. In the calcitic shells little alteration occurred in the configuration of most of the small segments of the valves (Pl. XIV, fig. 1b) which were compressed and stretched. Pl. XV, fig. 9, shows clearly the small " step-faults " in the calcite of a shell along transverse cleavage planes, preserved on the surface of a cast. The relation between the spacing of these planes and the size of the replaced structural elements of the shell is such that small structures such as hinge teeth were not obliterated but either yielded to stress as well as the coarser parts, or were even less affected. The step-like surfaces of the sheared calcitic shells cannot be freed mechanically from the matrix.

Although it is somewhat hazardous to describe as new species fossils preserved in a highly altered rock which makes it impossible to determine their exact proportions and to recognise all details of the ornamentation of their shells, the most common species belonging to recognisable genera are here named for further reference. Even if further fossiliferous localities are found in this area they can hardly be expected to yield perfectly preserved specimens of the fauna as the rocks are regionally metamorphosed.

DESCRIPTION OF THE FAUNA.

(*a*) Lamellibranchia.

Genus *Cucullaea* Lamarck 1801.

The taxonomic position of the Mesozoic representatives of *Cucullaea* (*sensu lato*) has not been clearly established. Many authors make dictinctions of subgeneric rank between them and the typical Cainozoic *Cucullaea* (genotype *C. auriculifera* Lam. = *C. labiata* Solander). The oldest name for a pre-Tertiary *Cucullaea*-like genus is *Cyphoxis* Rafinesque 1819, but this name is rejected by Wade, Cox and other authors who point out that it was based on unidentifiable casts. This would make the later designation *Idonearca* Conrad 1862 available. The genotype is *I. tippana* Conrad (a synonym of *C. vulgaris* Morton, from the Upper Cretaceous). A new genus *Ashcroftia* was described more recently by Crickmay (1930), with *A. inversidentata* from the Middle Jurassic of British Columbia as the only species. It differs mainly in the arrangement of the hinge. The central pair of teeth forms an inverted V, with about 3 oblique teeth on either side, followed by 3–4 sloping, elongate, hooked teeth. Crickmay states that probably many of the Jurassic *Cucullaea* belong to *Ashcroftia* and without mentioning Lower Cretaceous species goes on to say that *Latiarca* Conrad and *Idonearca* Conrad are the Upper Cretaceous and early Cainozoic forebears of the later Cainozoic and Recent *Cucullaea* s. str. Arkell (1936) accepts *Ashcroftia* as a new " subdivision " of *Cucullaea*. Two other subgenera may be mentioned briefly for comparison. *Dicranodonta* Woods 1899 (subgenotype *C. donningtonensis* Keeping) from the Lower Greensand is distinguished by long ventrally curved lateral teeth which are nearly parallel and often bifurcating. There is a pronounced difference between them and the small median teeth, which are vertical

and become oblique laterally. The hinge structure of *Cucullona* Finlay and Marwick (subgenotype *C. inarata* Finlay and Marwick) from the Danian of New Zealand and the Lower Eocene of Victoria resembles that of *Dicranodonta*. In the two last-named subgenera the valves have crenulated margins.

Cucullaea (*Ashcroftia*) *distorta* sp. nov.

(Pl. XIV, fig. 1–4 ; text-figure 3.)

Material.—Internal casts and partial external moulds of six specimens.

Holotype : Melbourne University Geology Department No. 1949 (Pl. XIV, fig. 3).

Most casts are of single valves which are greatly distorted but show hinge and area structures clearly. The surface sculpture of the valves is mostly obscured or obliterated. One specimen consists of the internal cast of two distorted valves which are slightly separated, showing the cast of the hinge between them ; the umbonal portions are broken off (Pl. XIV, fig. 2). Another specimen shows the internal cast and external mould of a large single valve which is dorso-ventrally flattened ; the space once occupied by shell material is now filled with spheroidal bodies of matrix connected by narrower bridges. This is clearly the internal cast of the borings produced in the shell by a sponge related to *Cliona* (Pl. XIV, fig. 1a, b). Similarly shaped but phosphatic casts on a lamellibranch from the Senonian of Texas were described as *Cliona microtuberum* Stephenson (Univ. Texas Bull. 4101, p. 54, 1941).

Occurrence.—Frequent in fossiliferous greywacke, Kaindi Metamorphic Group, Snake River, 20 miles north of Wau, Morobe District, New Guinea.

Diagnosis.—A large *Cucullaea* with a wide area with 6–10 chevron-shaped ligament furrows ; 18–20 well-developed hinge teeth, diverging outward and downward from the median plane ; the median group grading into the two lateral groups each consisting of 4–5 long sloping partly hooked teeth. Valve margins smooth.

Description.—Large, thick-shelled, inflated valves. Surface sculpture not well preserved but probably radials well developed on right valve ; left valve apparently almost smooth. Valve margins not crenulated. Area flat and very wide, with six to ten chevron-shaped, slightly sinuous, widely and regularly spaced ligament furrows. Hinge consisting of 18 to 20 strongly developed and clear-cut teeth ; about half this number occupying the median part of the hinge margin, divergent from the median plane of the valve and sloping ventro-laterally ; they are followed without a sharp break by 4 or 5 lateral teeth which are longer and sloping at a lower angle in a ventro-lateral direction ; some of the lateral teeth are hooked, particularly in the anterior portion of the hinge. It is possible that a weak raised ridge was developed on the median side of one of the adductor scars, but distortion makes this observation uncertain. The existence of an umbonal ridge is similarly uncertain. Length of hinge estimated at 40–50 mm., greatest height of valve probably about 50–60 mm.

Fig. 3.—*Cucullaea* (*Ashcroftia*) *distorta* sp. nov. Reconstruction of hinge, with generalised outline.

Comparison.—This species differs from *C.* (*Ashcroftia*) *inversidentata* mainly in the greater number of hinge teeth. It is distinguished from *C.* (*Dicranodonta*) *donningtonensis* and from the species of the subgenus *Cucullona* Finlay and Marwick by the lack of crenation of the valve margin and by the strongly developed median teeth which grade into the lateral series. This serves to separate the new species from the typical *Idonearca*, *Latiarca*, and *Cucullona* while the ventro-lateral slope of the teeth is different from that in the typical *Cucullaea*. A comparison of Crickmay's figure of *Ashcroftia inversidentata* (1930, pl. 2, fig. d) with Wade's figure of *Cucullaea* (*Idonearca*) *vulgaris* (1926, pl. 9, fig. 3) shows that the differences between these subgenera are not fundamental as the Upper Cretaceous species also possesses sloping hooked lateral teeth developing more or less gradually out of the median series. The median teeth are less regular, more numerous, and smaller. The hinge of the new form resembles that of the Jurassic species more closely but its larger number of teeth places it morphologically in a somewhat intermediate position between *Ashcroftia* and the typical *Idonearca*.

Genus *Glycymeris* da Costa 1778.

Glycymeris sp.

(Pl. XIV, figs. 5, 6 ; text-figure 4.)

Material.—10–12 internal casts, mostly showing the hinge structure well preserved. Sample localities include 45 (*see* map, fig. 1), and 12 (1 mile south of 45).

Occurrence.—Frequent in fossiliferous greywacke, Kaindi Metamorphic Group, Snake River, 20 miles north of Wau, Morobe District, New Guinea.

Description.—Shell rounded, small, up to about 25 mm. in diameter ; valves subcircular, apparently gently vaulted. Dorsal margin straight, ventral margin rounded, internally crenulated, with approximately 35 crenulations visible in one of the valves (Pl XIV, fig. 5) Ligamental area not clearly preserved, probably small. Hinge plate wide and high. 8–10 small vertical median teeth are followed laterally without a break by 5–6 larger chevron-shaped radial to transverse lateral teeth which are somewhat larger but not elongated. The raised areas bordering the adductor scars are faintly visible in the distorted casts. The external surface is not well preserved, but indications of faint radial ribs are visible in an external mould of the lateral portions of a valve.

Fig. 4.—*Glycymeris* sp. Reconstruction.

Remarks.—The casts of the hinge teeth are preserved in a manner which gives the fossil the general appearance of a nuculid, but when impressions are taken and examined the transverse position and chevron-like shape of the lateral teeth become clearly visible. As neither the outlines and curvature of the valves nor their surface sculpture are clearly visible specific identification of this fossil is impossible. It is comparatively common.

Genus *Trigonia* Bruguière, 1789.

The taxonomy of this important group of lamellibranchs was discussed in recent years by Crickmay (1932) and Rennie (1936). It seems advisable to recognise the divisions listed by Crickmay and at least some of those subsequently proposed by other authors, but to consider them as subgenera as suggested by Rennie.

Sculptured external moulds of *Trigonia* valves in the collection from the Snake River indicate that several species belonging to more than one of the subgenera are present, but only one species is represented by sufficient material to justify a description.

Trigonia (*Acanthotrigonia*) *phyllitica* sp. nov.

(Pl. XV, figs. 7, 8.)

Material.—Holotype : Cast and external mould of a right valve, compressed but with the outline and ornamentation of the area and the posterior portion of the shell comparatively well preserved. Melbourne University Geology Department, No. 1951.

Paratype A.—Smaller left valve preserved as a perfect cast of the umbonal and hinge region, with external mould of the anterior portion (sample 47). Melbourne University Geology Department, No. 1952.

Paratype B.—Immature specimen (sample 45). Also various casts and moulds of fragmentary specimens. Melbourne University Geology Department, No. 1953.

Occurrence.—Rare in fossiliferous greywacke, Kaindi Metamorphic Group. Snake River, 20 miles north of Wau, Morobe District, New Guinea.

Diagnosis.—A small *Trigonia* with sub-parallel diagonal ridges on the area. forming along the blunt marginal ridge acute angles with the oblique tuberculate sharp flank ribs.

Description.—Shell small, valves triangular, anterior margin convex, postero-dorsal margin slightly concave, posterior end rounded. Area and escutcheon wide, separated from the flank of the valve by a blunt ridge without a distinct keel. The costæ of the posterior portion of the flank (10 in the holotype) commence at this ridge which becomes indistinct towards the margin. Area wide, convex ; junction with escutcheon not preserved. Escutcheon (of an immature specimen, paratype B) apparently ornamented with ribs bearing strong beads. Area covered with fine but distinct sub-parallel ribs which are slightly concave toward the umbo and cross the area diagonally from the marginal carina inward and backward towards the postero-lateral valve margin. They become obsolescent near the lateral edge of the valve. The flanks are ornamented with about 20 oblique, sharp, almost straight costæ on which small protuberances are regularly arranged. A distinctive feature of the ornamentation is the acute angle (45–60°) between flank and area ribs where they meet on the marginal ridge. Inner valve margin crenulated. Casts of finely ribbed large hinge teeth are preserved in several specimens. Height of holotype valve about 30 mm., estimated length about 40 mm.

Remarks.—The present species is assigned to *Acanthotrigonia* van Hoepen not so much because of its relation to the subgenotype (*Trigonia shepstonei* Griesbach from the Upper Cretaceous of East Africa) as its clear connection with the " *spinosa*-group " of the " scabrae." This group was first distinguished by Lycett (1875, p. 115), and Crickmay (1932) concluded his description of *Acanthotrigonia* with the following statement : " This genus is the group of the spinose scabrae and is quite distinct from other groups of scabrae." Of the distinguishing features listed by Crickmay after van Hoepen (1929) the following can be seen in the present specimens : The " moon-shaped trigonoid " outline, moderately incurved opistogyral umbo. tuberculate costae which are sharply triangular in cross section and which approach the area at an acute angle, transverse costellae of the area, obsolete carina and crenulate interior valve margin. This subgenus is restricted to the Cretaceous.

Genus *Cardium* Linnaeus, 1758.

Cardium sp.

(Pl. XV, figs. 9, 10.)

Five large internal casts of a large cardiid shell include specimens from sample localities 39, 40 and 43. They are all higher than long, the largest reaching a height of 80 mm. and a length of 50 mm. The hinge teeth are strong, the laterals and one strong triangular cardinal tooth being preserved in most of the casts ; the interior valve margin is finely crenulated. The surface ornament is not known.

Genus *Volsella* Scopoli.

Volsella sp.

(Text-figure 5.)

A single specimen from sample locality 26 is assigned to this genus. It is represented by the anterior half of a slightly distorted internal cast, 85 mm. long and 75 mm. high. The distortion which is illustrated in fig. 5b has depressed the

Fig. 5.—*Volsella* sp. a—reconstruction of outline, b—diagrammatic anterior view with reconstruction.

umbones below the dorsal margin giving the shell a somewhat *Pteria*-like general appearance, but closer inspection shows them to be well removed from the anterior end of the valve and just below the position to which they have been restored in the accompanying outline drawing.

Genus *Inoceramus* Parkinson.

Inoceramus sp.

The occurrence of this genus in the fossiliferous beds on the Snake River was established by Whitehouse (personal communication). External moulds of fragmentary shells with strong concentric sculpture which were found at sample locality 37 are also assigned to *Inoceramus*.

LAMELLIBRANCHIA indet.

A number of casts of heterodont inequilateral flat valves of *Tellina*-like general appearance have been observed but are too poorly preserved for identification. They occur at sample localities 13 and 15.

(*b*) GASTROPODA.

Genus *Tibia* " Bolten " Roeding, 1798 (*Rostellaria* auct.)

A gastropod with its outer lip extended to form a well-developed wing ending in lobate and scythe-shaped digitations seemed to resemble certain Cretaceous Aporrhaidæ of a group including the genus *Anchura* Conrad. However, when the outline was reconstructed from several slightly distorted individuals and the drawing sent to Dr. L. R. Cox, with a request for an opinion on the generic position of this fossil, Dr. Cox replied that it was unlike *Anchura* and difficult to place but that it could perhaps be included in *Tibia* (= *Rostellaria* auct.) *sensu latissimo*. The diagnostic features involved can be best explained by quoting A. Morley Davies (1935, pp. 262–3): "The safest distinction between the two families (*i.e.* Aporrhaidæ and Strombidæ) appears to be the relation of growth-line to suture. . . . A less satisfactory distinction is the absence of a true anterior notch in Aporrhaidæ, that family being rather rostrate holostome than truly siphonostome." The growth-lines cannot be seen distinctly in the present fossils, but the anterior notch is clearly visible in at least two specimens.

Tibia (?) *morobica* sp. nov.

(Pl. XV, fig. 11, 12; text-figure 6.)

Material.—Internal casts and external moulds of at least four specimens, two of them showing the labrum with well-preserved outline but somewhat extended by distortion, and traces of surface sculpture.

Holotype.—Melbourne University Geology Department No. 1950. (Pl. XV, fig. 11.)

Occurrence.—Frequent in fossiliferous greywacke, Kaindi Metamorphic Group. Snake River, 20 miles north of Wau, Morobe District, New Guinea.

Diagnosis.—Shell elongate, labrum consisting of an anterior lobe and a hooked main wing ending in a scythe-shaped posterior projection. Weak longitudinal ridges on the earlier whorls.

Description.—Shell with about 5 whorls, apparently short and wide, with smooth and gently convex outline; sutures distinct, depressed. Outer lip forming a broad wing with a distinct posterior scythe-shaped projection (not preserved in the holotype). It is separated by a deep rounded sinus from a shorter rounded anterior digital extension; a distinct anterior notch is developed between it and the short anterior canal which reaches about $\frac{1}{4}$ of the length of the last whorl. The labrum extends nearly to the upper edge of the preceding whorl. A strong internal marginal thickening is found on the outer edge of the main projection of the labrum which generally does not appear to have been thick or callous. The surface ornamentation was apparently weak, consisting of blunt longitudinal ridges which disappear on the last whorl. There are only faint traces of spiral ornamentation.

Fig. 6. *Tibia ? morobica* sp. nov. Reconstruction.

Measurements.—Holotype : About 18 mm. long, 6 mm. wide, length of labrum between anterior and posterior notches 6 mm., distance of wing tip 7 mm. Paratype A : About 23 mm. long, 10 mm. wide (crushed), anterior canal about 7 mm. long, distance between wing tips 15 mm. Paratype B : Length from apex to base of anterior canal about 25 mm., greatest width 28 mm. (crushed). The outline of the labrum does not seem to be greatly affected by distortion of the specimens but reconstruction of the proportions of the spire is difficult and actual measurements are uncertain.

GASTROPODA indet.

Several external moulds indicate the occurrence of other types of gastropods which are not sufficiently well preserved for identification. (Sample localities 28, 37.) They include a low-spired trochoid shell and an external mould of a fairly large form possibly representing the Volutidæ.

THE AGE OF THE SNAKE RIVER FAUNA.

The following fossils have been identified from the Snake River greywacke which forms part of the Kaindi Metamorphic Group in the Morobe District of Central New Guinea :—

SPONGIÆ.

Cliona sp. (borings in shells of *Cucullaea*).

LAMELLIBRANCHIA.

Cucullaea (Ashcroftia) *distorta* sp. nov.
Glycymeris sp.
Trigonia (*Acanthotrigonia*) *phyllitica* sp. nov.
Cardium sp.
Volsella sp.
Inoceramus sp.

GASTROPODA.

Tibia ? morobica sp. nov.

This is clearly a Mesozoic fauna. As no known species could be recognised in it, its age can be fixed only by means of an examination of the stratigraphic ranges of the genera represented. *Cucullaea* is known from Jurassic to Recent. The subgenus *Ashcroftia* to which the species from the Snake River has been assigned is known only in a single species from the Jurassic. The taxonomy of the Mesozoic representatives of *Cucullaea* has not been studied in sufficient detail to exclude the possibility that other species, possibly of different age, could also belong to that subgenus. Besides. the new species is intermediate in its hinge structure between *Ashcroftia* and the Upper Cretaceous type species of *Idonearca*. The conclusion that the new species of *Ashcroftia* must also be Jurassic would therefore be unjustified. A Cretaceous age of the fauna is clearly indicated by the occurrence of a *Trigonia* of the subgenus *Acanthotrigonia* which is restricted to the Cretaceous (Crickmay 1930) and has a wide geographic range. This is supported by the discovery of *Glycymeris* which is not known from pre-Cretaceous strata. The ranges of the other genera recorded from the Snake River fauna are in agreement with Cretaceous age which is therefore accepted.

At the present state of our knowledge it is difficult to arrive at a more definite conclusion. None of the fossils recorded makes it possible to place the fossiliferous strata definitely in any particular part of the Cretaceous System. There are however certain considerations favouring a position within the interval from Aptian to Albian or Cenomanian. There is a definite resemblance in lithology and facies with the Purari Formation (Carey 1945, Glaessner 1945). This formation which has been placed in the Aptian-Albian contains a fauna dominated by lamellibranchs (including *Trigonia* but not *Cucullaea*) and the gastropod *Anchura* which occur in " lumachelle"-like concentrations in a sequence of unmetamorphosed strata mostly composed of shales and greywacke (Edwards 1947). The group of *Trigonia* represented in the Snake River fauna seems to be more characteristic of the later than the earlier part of the Cretaceous. Finally, Late Cretaceous faunas are very well known throughout the Pacific Region and none of their distinctive elements has been found in the fauna here described. These are admittedly only weak indications but they justify the expectation that this Cretaceous fauna will eventually be found to be younger than Neocomian and older than Senonian.

THE SIGNIFICANCE OF THE SNAKE RIVER FAUNA.

The discovery of this fauna by Whitehouse, the collections and observations made by G. A. V. Stanley and the determination of its age as Cretaceous have a far-reaching importance for the geology of New Guinea. The significance of these discoveries is three-fold. Firstly, they indicate that the intrusion of the Morobe batholith which according to N. H. Fisher and G. A. V. Stanley affected the Snake River beds occurred not earlier than the Cretaceous. Secondly, they suggest localization of the metamorphism affecting the Kaindi Group (contact and dynamo-metamorphism), as sediments of the same age are known to be entirely unmetamorphosed over a large area of the Central Highlands west of the Miocene Aure Trough. Thirdly, they make it likely that metamorphic strata resembling the Kaindi Group which have been described from other parts of the New Guinea area may also prove to be Cretaceous. The distribution of metamorphosed and unmetamorphosed Cretaceous indicates that structural trends in this area are less simple than had been assumed (fig. 7).

(*a*) The Age of the Morobe Batholith.

The Morobe batholith was mapped, described, and named by Fisher (1944). It is about 50 miles long and 25 miles wide, extending north-east and south-west of the Wau-Bulolo goldfields area, which occupies a saddle-shaped transverse depression in its central part. The principal intrusive rock is described as " a slightly acidic granodiorite, or adamellite," which " has been the direct source of a considerable proportion of the gold mineralisation." The age of the Kaindi metamorphics which it intrudes could not be directly determined prior to the discovery of the Snake River fossils. The only evidence for the age of the intrusion available to Fisher was the observation that in places along its western margin the granodioritic mass was overlain by volcanics followed by Tertiary sediments containing boulders of the " granite." The age of the Tertiary marine sediments in this area (Langimar valley) was determined by the Commonwealth Palæontologist (Miss Irene Crespin) in unpublished reports as Middle Miocene and the basalts intervening between the

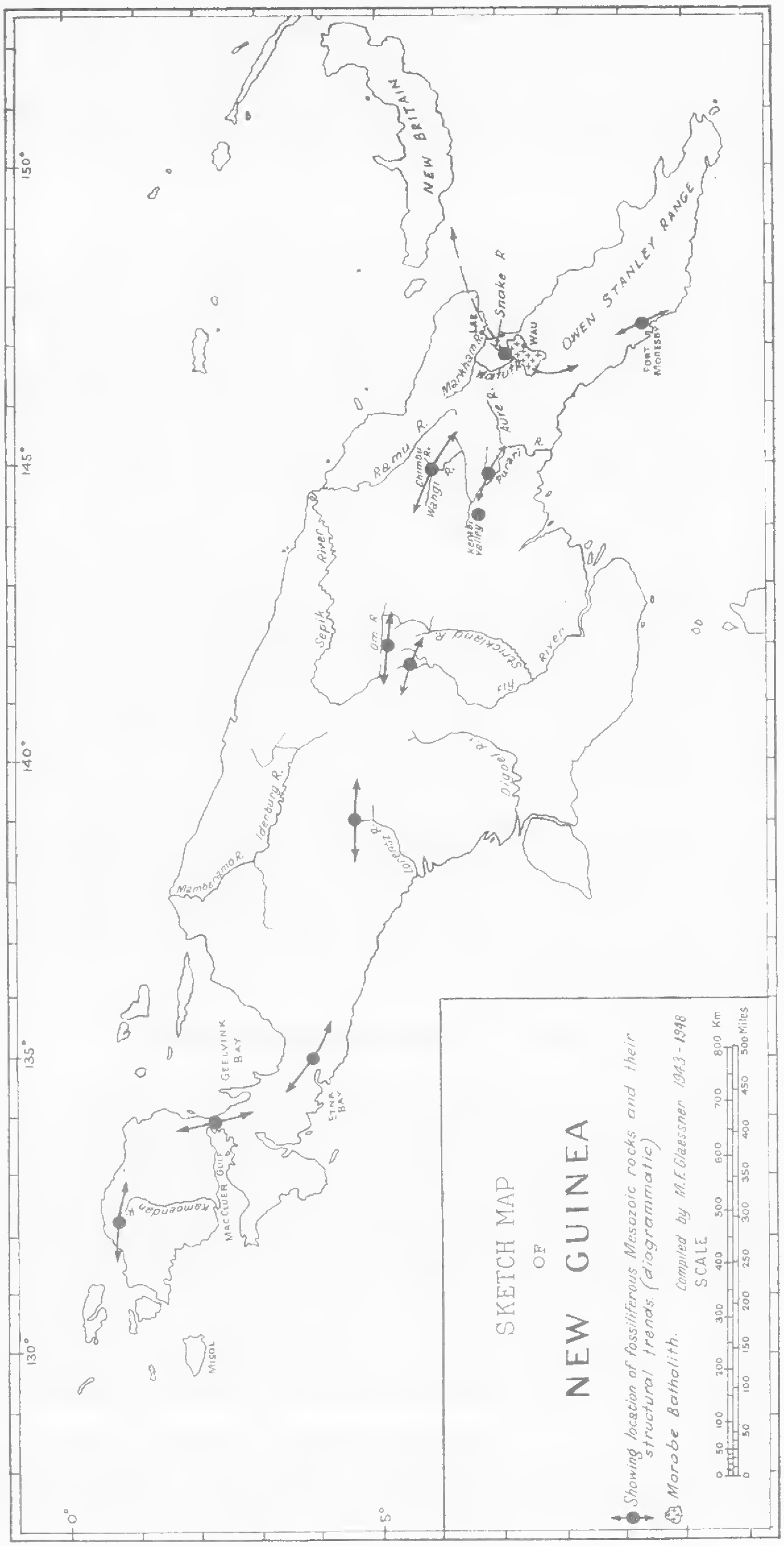
SKETCH MAP
OF
NEW GUINEA
Showing location of fossiliferous Mesozoic rocks and their structural trends. (diagrammatic)
Morobe Batholith.
Compiled by M.F.Glaessner 1943-1948
SCALE
NEW BRITAIN
OWEN STANLEY RANGE
Snake R
WAU
FORT MORESBY
Markham R.
Watut R.
Ramu R.
Sepik River
Strickland R.
Fly River
Digoel R.
Idenburg R.
Mamberamo R.
GEELVINK BAY
ETNA BAY
MACCLUER GULF
MISOL
150°
145°
140°
135°
130°
0°
5°

Fig. 7.

"granite" and the marine beds are probably Lower Miocene or Upper Oligocene. This left a very wide margin for the age of the intrusion and Fisher's conclusion was that it was possibly as early as late Palæozoic but probably Mesozoic. Having placed the Snake River beds in the middle part of the Cretaceous we are forced to the conclusion that the batholithic intrusion took place in Late Cretaceous or Early Tertiary time.

(b) Metamorphosed and Unaltered Mesozoic Rocks.

It has been stated that in Netherlands New Guinea some Mesozoic rocks, believed to be mainly Jurassic, had been altered to phyllites ("glansleien"), but available data are insufficient for a discussion of the circumstances and areal distribution of this alteration. In a large portion of the Central Highlands of the Australian part of New Guinea a thick sequence of Jurassic and Cretaceous rocks is known to be developed as an unaltered gently folded series of rocks (Osborne 1945, Carey 1945, Glaessner 1945). Evidence of the occurrence of granites of higher age than that now established for the Morobe Batholith is found in the occurrence of granitic pebbles in the Jurassic of the Fly River and in a component of granitic origin in the Purari greywacke of Aptian-Albian age (Edwards 1947). Large granite masses appear underneath the Jurassic at the base of the thick unaltered sedimentary series of the Wahgi valley and were originally considered as part of the basement, but alternative interpretations of the field evidence have been suggested. In any case the fact remains that a thick series of unaltered sediments ranging from Upper Jurassic to Cenomanian (with interruptions) is developed in the Central Highlands from the International boundary to the Tertiary zone extending across the island from the Lower Purari River to the Lower Markham (Aure Trough, Beltz 1944). East of this Tertiary trough is the type area of Fisher's Kaindi metamorphics which at least in part can now be correlated with a portion of the Wahgi and Purari sedimentary series. No unaltered rocks older than uppermost Senonian have so far been described from the eastern part of New Guinea. These relations suggest an important difference in the Late Cretaceous and Tertiary history between the areas east and west of the Aure Trough.

(c) The Trend of the Kaindi Metamorphics.

Fisher (1944) described the structure of the Kaindi Group as "a series of broad folds trending in a generally northeast-southwest direction." Eastwest to southeast-northwest strikes were observed in the central goldfields area of Wau-Bulolo, which is situated in a transverse saddle across the main north-east-south-west axis of elongation of the batholith. A statistical analysis of strikes measured in the Kaindi metamorphics, mainly by Fisher and Noakes, and including those measured recently by G. A. V. Stanley in the Snake River area, confirms Fisher's statement and shows clearly that the folding in this area, with which the elongation of the batholith conforms in the usual manner of such intrusions, is not parallel to the main axis of the island of New Guinea. It is parallel to the axis of the Tertiary Aure Trough which seems to have developed as a foredeep in front of this folded zone.

The Morobe area with its metamorphic Mesozoic strata is part of an arcuate folded structure of Late Mesozoic and Early Tertiary age. It develops out of the north-westward trend of the Owen Stanley Range in Papua at about lat. 147°, thence

swinging northward, north-eastward and eastward towards the Huon Gulf between Lae and Salamaua. Its prolongation may form the basement of the Tertiary rocks of the Rawlinson Range between Lae and Finschhafen, and emerge again as the metamorphic and plutonic basement of the Whiteman and Nakanai Ranges of New Britain, described by Noakes (1942) as a series of schists and phyllites resembling the Kaindi metamorphics and likewise intruded by a granodiorite.

It was stated in an earlier publication on Mesozoic fossils from New Guinea (Glaessner 1945, p. 162): "The known pre-Tertiary basement in a wide zone including the northern coastal ranges of New Guinea, the Bismarck Archipelago, the Solomon Islands, New Hebrides, Fiji and Tonga consists entirely of metamorphic or plutonic rocks." As far as pre-Upper Senonian rocks are concerned, this statement could also apply to the Morobe Arc and its continuation in the Owen Stanley Ranges (where both metamorphosed and unmetamorphosed *Globotruncana*-rocks of Upper Senonian age occur in the Port Moresby area). It should be qualified by the remark that the metamorphics may include locally less altered fossiliferous beds; that Cretaceous fossils occur in them in the Morobe area; and that similar fossils can be expected to occur locally under favourable circumstances elsewhere in the area outlined above, particularly in New Britain.

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PLATE XIV.

1a

3

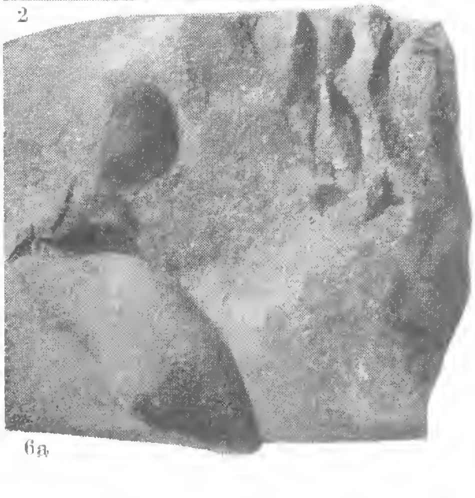
1b

2

5

4a

4b



6a

6b